TALLYN

Design of a Steel Railroad Warehouse

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OF A

STEEL RAILROAD WAREHOUSE

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Louis Liston Tallyn

ENTITLED Design of a Steel Railroad Warehouse

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering.

Ira O. Baker,

HEAD OF DEPARTMENT OF Civil Engineering.

DESIGN OF A STEEL RAILROAD WAREHOUSE

INTRODUCTION

In choosing a thesis subject I have endeavored to select one that would be of practical use to me in the work that is to follow the college training. I have decided to present the design of a steel railroad warehouse at New Orleans for the Illinois Central Railroad as I am greatly interested in railroad work and intend to make that my speciality and because the design of warehouses has so far received only little consideration, but chiefly because a careful study of such a subject will give a knowledge of steel structural work.

8 PRINCIPLES APPLICABLE IN THE DESIGN OF RAILROAD WAREHOUSES

Nearly all railroad warehouses are of wood,

but if a warehouse were to be built today it is certain that, except for small buildings and in localities where timber is exceptionally cheap, a wooden warehouse would not be considered. At present steel seems to be the material which most nearly approaches the ideal for such structures. This use of steel is due to the increase in the cost of timber and to the decrease in the price of structural steel, which now makes it possible to build a much stronger, a better looking, and more economical structure than would have been possible ten years ago.

With a steel structure a settlement of a couple of inches would not in the least impair its efficiency, as the members would adjust themselves by flexure to meet the new condition. This property of a steel structure is of great advantage where the foundations must be located in soil saturated more or less

with water, as would be the case near
the sea or a large river. Where brick or stone-
work is built on such foundations, the masonry
would be quite likely to crack.

Large freight houses have in the past
fifteen years generally been built with a
wooden frame covered with sheathing or
corrugated iron, and with wooden or combination
roof trusses covered with gravel, tin, iron or
some form of patent roofing-felt which is
supposed to be fireproof. To cheapen the con-
struction, a flat roof is frequently used; but
this style of roof is very hard to make absolutely
water-tight. Again, where corrugated iron is
used as a roof covering the wind has a tendency
to drive the rain up under the iron. It is
claimed that tin or iron when used on a
building near salt water, deteriorate rapidly
and that a gravel roof would be much
better; but if the iron or tin is kept well

painted, there is little danger of its being
attacked in that way. When tin or corrugated iron is used as a roof, the trusses may be built much lighter than when gravel is used.

Freight houses are often built very long, for example, the Illinois Central banana sheds at Cairo, Illinois. Here, as at all long warehouses, the length of train standing on the track becomes excessive, and in switching the work of the "banana hands" is often interrupted, while if a train is made up by loading successive cars, they are sometimes detained longer than is advisable. Fifteen hundred feet is probably as long as a warehouse should be. Freight houses should probably not be more than two hundred feet wide, since otherwise freight taken directly from the cars to the vessels must be trucked too far. On the other hand, where package conveyors are used, this would matter little; and the wide

warehouse would have greater floor space 5
for the same cost of construction. If a large amount of freight is loaded direct from the cars to the vessels, it may be well to run a track between the freight house and the pier; but at most docks, unless space is very valuable, such freight will be handled at a pier independent of the warehouse.

Where ground space is valuable, a second story is added. This gives a good space for long-storage freight, where it will be out of the way. When the value of barrel and package elevators come to be properly appreciated, two-story warehouses will be built to a greater extent than now.

Doors are introduced in the sides of the building at intervals to allow the freight to be taken in and out. Where the doors are too close, a great deal of space is occupied by passageways, and is therefore

rendered useless for the storage of goods. 6
On the other hand, where the distance between the doors is great, the number of berths for vessels is diminished. In single story warehouses, windows in the sides of the building are usually omitted, and light and ventilation is obtained by skylights in the roof, or sometimes only by transoms over the doors. In double story houses the upper floor is often extended across the track-pit so as to utilize the entire ground space for storage, in which case it is necessary to locate windows in the sides of the lower story. Where this is done the windows must be set so high as not to be blocked by freight piled along the sides of the building. A better design is to omit the floor over the track-pit, which reduces the storage space, but also secures an abundance of light and ventilation for the lower story as well as avoids a costly

girder construction over the track-pit.

DESCRIPTION OF SOME WAREHOUSES

Before considering the details of the proposed design, a short description of some railroad warehouses will be given. These are not all sea-board warehouses, but they are good examples of current practice. The descriptions are taken from blue-prints sent by the railroads.

Michigan Central Freight House, Grand Rapids, Michigan. This is a single story structure, 480 ft. long, and 48 ft. wide sheathed on the sides with galvanized iron, and roofed with tin. The clear height of the building is 11 ft. 9 in. The bents are 15½ ft. by 16 ft. The 12 x 12 in. wooden columns are supported on stone foundations 4 ft. square, having a depth below the ground of 8½ ft. At the north end, 36 ft of the structure is two-storied the second story being used for offices, toilet rooms etc.

One peculiar thing about this warehouse
is that it has what may be called a continuous door system by which an opening may be made at any point along the side of the building.

Union Pacific Railroad Standard. The standard freight house for this road is a one-story structure built of brick laid in lime mortar. The foundation is of rubble laid in cement mortar. Above the ground the masonry is range work with 1/4-in. joints. The masonry is built up to the underside of the roof boards between the rafters. The door jams are formed of cast iron columns, on which are placed two nine-inch I beams with cast iron separators, on which the wall is continued to the roof. In the office portion the walls are covered with 3/4 x 1/2" in furring strips. The building is covered with a combination roofing-felt.

Chicago St. Paul Minneapolis + Omaha

Railroad The warehouse at Allouez Bay
Docks is 1500 ft. long by 80 ft. wide. The sides are covered with No. 24 corrugated iron, and the roof with tin. The entire building is founded on 10-in oak piling, with the exception of the fifteen feet towards the bay which is built upon 12x12-inch cribwork. Just inside the doors of the warehouse are six platform scales. three on the west or receiving platform and three on the east or delivery side. The doors are white-pine frames covered with No. 26 corrugated iron.

The warehouse of the same road at Duluth is of the same general type, the main difference being that along the sides of the pier movable inclines or gangways are provided which follow the rise and fall of the water and which can be adjusted to suit any boat whether floating high or low in the water. The principal material used in these

buildings is creosoted yellow pine, the 10 caps and stringers being 12 x 12-inch, and the posts 10 x 10-inch. The roof trusses are of white pine.

Atchison Topeka + Santa Fe' Railroad. The freight houses of this road are much the same as those of the Chicago, St. Paul, Minneapolis and Omaha railroad, except that more pains have been taken with the appearance of the structures.

Mobile and Ohio Railroad. The standard freight house of this road is a double-story frame structure, 560 ft. long by 80 ft. wide, sheathed on the outside with galvanized iron, and roofed with a composition roofing-felt. Two tracks enter the building, one near the side and one in the middle. The former is for freight which requires no storage. By the use of iron joists and girders, the floor of the second story is continued without a break

across the track-pit. Freight is trans- 11
ferred from and to the upper story by package elevators.

THE WRITER'S DESIGN

The site for the warehouse has been taken at New Orleans, Louisiana, on the property of the Illinois Central fronting the gulf known as Stuyvesant Docks. The design, however, is adapted to any sea-board town where a great deal of heavy freight is received from railroads for shipment by water or vice versa. It might also with a few variations be suitable for an inland town.

The warehouse will be 600 ft. long. This length is chosen because it represents the length of wharf available for that purpose. The width of the building will be 148 ft, of which 28 ft. in the center will be occupied by two tracks spaced fifteen feet center to center, which allows an ample passage-way between

the tracks and also between the floor and the track.

Load. The size of warehouse having been decided upon, the next thing is to select the proper floor load to be allowed for. This depends upon the class of freight to be expected and also upon the manner of storing it. Passage-ways will at most times be left in the freight for accessibility, which will make some difference in the loading; but as the passage-ways are likely to be omitted at some time, the unit load should be on the side of safety and cover all contingencies. A load of 200 lbs per. sq. ft. on both the upper and lower floor has been taken in this design, which it is believed will be ample as iron ore, lead, etc., will not be stored here.

Support of Upper Floor The columns will be spaced 20 ft. apart in the direction of the length of the building, and 15 ft. in the

other direction. The girders will run parallel to the length of the building and therefore the girders will be 20 ft. long and the joists 15. The economic length of the girders is somewhat less than 20 ft. but by this spacing of the columns more clear room will be obtained, which is a thing worthy of some consideration.

Roof Trusses. The vertical load on the roof will be taken as 35 lbs. per sq. ft. of horizontal projection, of which 20 lbs. is supposed to cover the weight of the roof itself, and 15 a possible load due to wind. The horizontal effect of the wind is taken as 30 lbs. per sq. ft. of the vertical projection. A design was first made in which it was intended to span 60 ft. with one Fink truss, but this required such heavy construction in the truss members, that the span of the trusses was reduced to 30 ft. and a column was projected up through the second story to carry one end of

the trusses.

For an elevation of the trusses see Plate III, page 23 The stresses in the several members of the trusses were found by graphical resolution. In many cases a stress was found smaller than would be safely carried by a 2x2-inch angle, but on account of riveting a smaller section would not be used. For details of the trusses see Plate III, page 23.

Purlins. The purlins are spaced 7 ft. apart and have a span of 20 feet This requires rather a heavy purlin, and on account of the length there will be more or less deflection in it; but this will not be in the least detrimental. Five-inch nine-pound channels will be used, and on these will be bolted the nailing pieces.

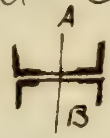
Roof Covering. Over the purlins will be laid 1½-inch pine sheathing covered with tin. Tin is used in preference to corrugated iron, as it may be soldered so as to be absolutely

water tight. On the underside of the sheathing will be nailed a layer of asbestos to prevent sparks from the engines below setting fire to the wood-work.

Flooring. The flooring for the upper story will be 3-inch well-seasoned long leaf yellow pine surfaced to a thickness and laid with square joints. The floor can safely carry the required load with a span of 4 feet, and therefore the joists will be spaced 4 feet center to center. The joists will be supported by girders which are in turn supported by the columns. The joists will be 15-inch 42 lb I beams, and the girders 20-inch 65-lb. I beams.

Columns. Only two columns will be designed: one having only a part of the roof to support, and one that supports this column and the load on the upper floor. The first is designated A on Plate II, page 23, and the second B.

Column A. The load due to the weight of

truss, wind and snow is 24000 lbs. A column composed of 4 angles $3\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{16}$-in. and $2 \times \frac{1}{2}$-in lacing will be used. The cross-section is shown in the figure . The moment of inertia about the axis AB = 20.4 X 4 = 81.6 inches, and the distance C, from the center of gravity of the cross section to the most extreme fibre, = 4. The bending moment, M, caused by the wind on the roof = 1,442,000 inch pounds. Substituting these values in the formula $M = SI \div C$ and solving for S, we obtain a value of 7100 lbs. per sq. in. The stress per sq. in. due to the weight of the trusses = 3300 lbs. Therefore the total stress = 7100 + 3300 = 10400 lbs. per sq. in. The allowable stress = $16000 - (45 \frac{l}{r})$. $\frac{l}{r} = 13.7$. Therefore the allowable stress = 11400 lbs. per sq. in.

Column B. The dead load caused by column A is 12 tons, and the load on the column due to the second floor is 41.5 tons making a total of 53.5 tons. The length of column is 12 ft.

Try a column composed of four $3 \times \frac{1}{2}$ in. Z
bars laced. Half of the wind pressure on the windward side above the floor is transmitted by the roof and the lateral bracing to the columns on the leeward side of the building, and half is carried directly by the columns on the windward side. The wind pressure to be resisted by 10 columns $= 46 \times 30 \times 20 = 27{,}600$ lbs. The columns being fixed at the base, the total moment of the wind $= 27{,}600 \times 12 \times 6 = 1{,}987{,}200$ in. lbs. and the moment resisted by one column $= 198\,720$ in. lbs. $I \div c$ for this column $= 85.1$. By substitution in the equation $M = SI \div c$, $S = 2300$ lbs. per. sq. in (approx) The area of the column $= 9.31$ sq. in; and the stress in the column due to the dead load $= 83\,000 \div 9.31 = 8900$ lbs per. sq. in.

The other columns will be stressed less than this one; but this section will be used throughout for the columns on the lower floor.

Wind Bracing. Only the method of

designing member AD (see Plate III, page 23) will be explained. The wind pressure to be transmitted = 4800 lbs. The secant of the angle of inclination = 1.06. Therefore the stress in AD = 4800 X 1.06 = 5100 lbs. A 3/4-in. round rod will be used.

In the same way the sizes of the members CE, EF, and FG are determined.

Foundation. The maximum load for the column is about 55 tons. The foundation will be built on piling, as experiments made by F. J. Llewellyn - Engineering News. May 11 1899 - show that the safe load for the soil at New Orleans is only about 700 lbs. per. sq. ft. Nine piles will be used in supporting each column. The depth of pile necessary to safely support the load will be found by driving a few trial piles and using what is known as the Engineering News formula. (Baker's Masonry Construction page 245) $P' = 2Wh \div d+1$, in which P = the safe load in tons; and d' is the

penetration in inches under the last blow. 19
W is the weight of the hammer in tons; and h is the fall in feet. The piles will be of good quality straight-grained white oak, and before being driven, the entire bark will be stripped off. No pile less than 15-in. at the top will be used. The piles will be spaced 3 ft. centers to centers. A detail drawing of the foundation is shown in Plate II, page 23. The concrete used in the foundation will be composed of 1 part Louisville Natural cement and 4 parts of sandstone broken to pass a 2½-in. ring, the part passing a ½-in. ring being screened out. The concrete is assumed to have a compressive strength of 10 tons per. sq. ft.; and then the area of the cast iron base to support the column will be 55 ÷ 10 = 5.5 sq. ft. A base 30 inches square will be used.

The first floor will be composed of 6-inches of concrete made as that for the foundation

resting directly on the ground. Over this 20 will be spread ½-in. of neat Portland cement to give the floor an even surface.

CONCLUSION

The writer realizes that he has not treated such details as cornices, gutters, window-frames, etc. but time will not permit of a further elaboration of the design.

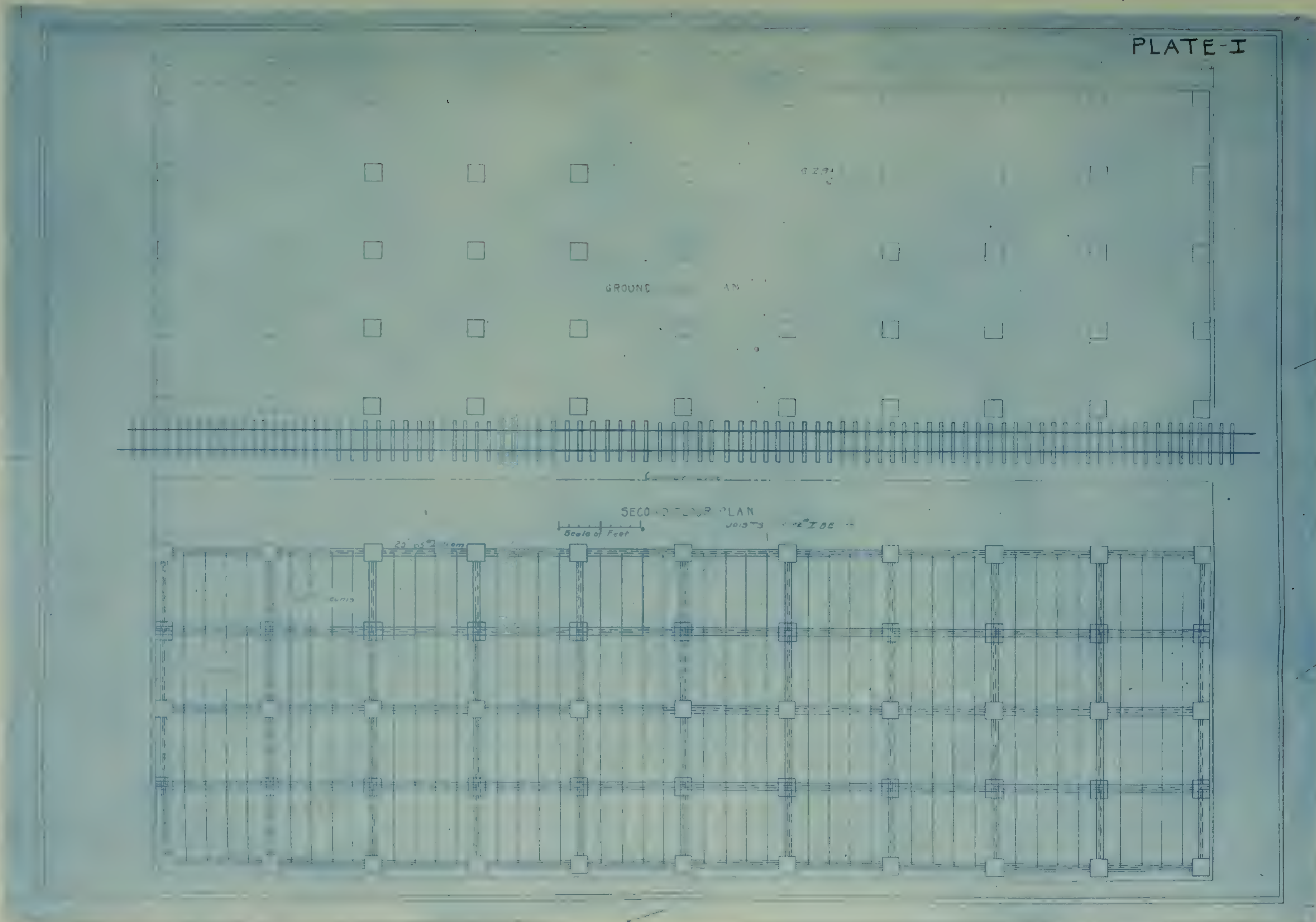


PLATE-I
Scale of Feet

PLATE-II

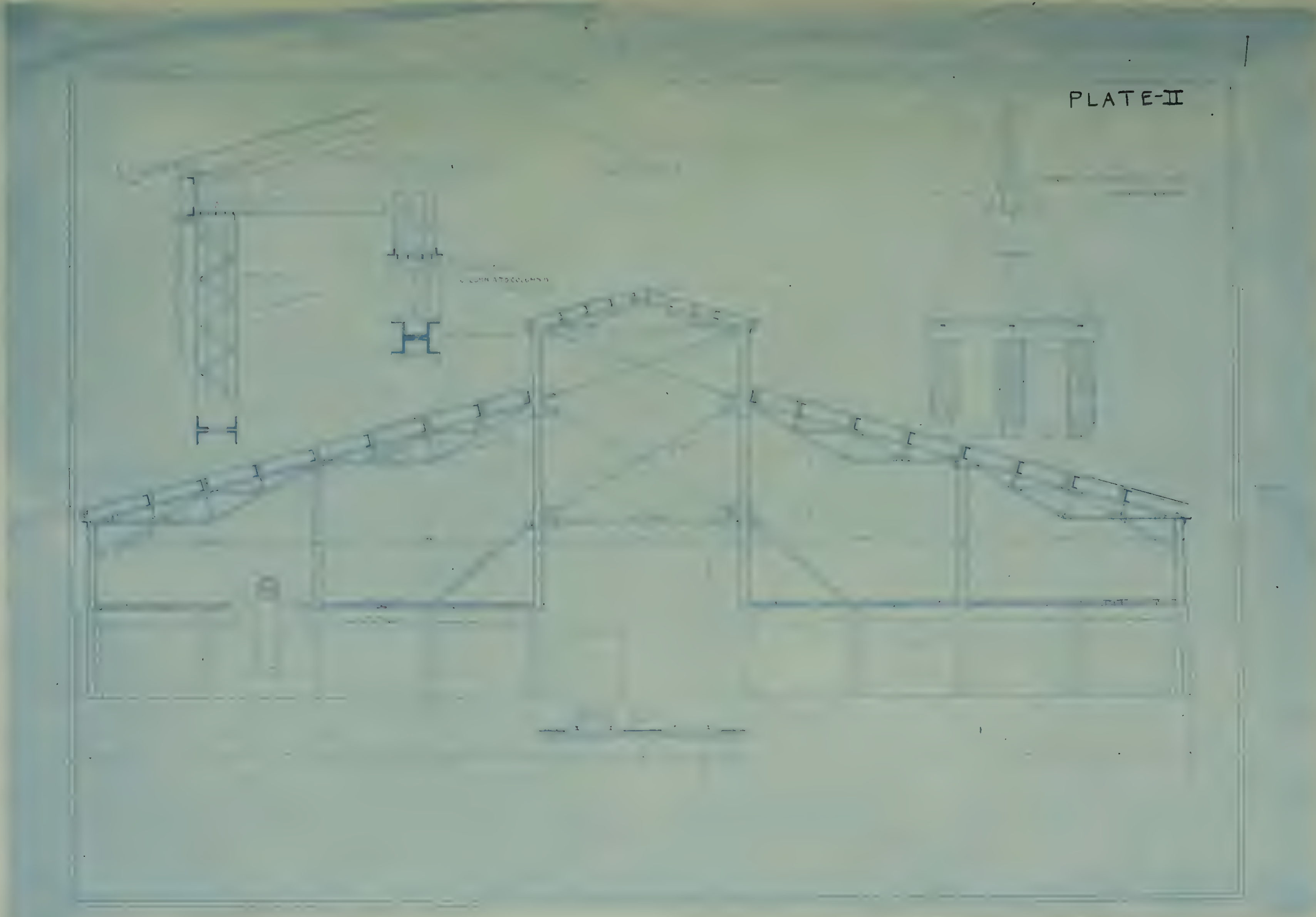


PLATE-III

SIDE ELEVATION